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INSTRUCTION MANUAL

REGULATED POWER SUPPLIES

MODELS LH 118, LH 118FM, LH 118S

BEARING SERIAL NO.

PREFIXES A - C

LAMBDA

LAMBDA ELECTRONICS CORP.-MELVILLE, L. I., N. Y.

INSTRUCTION MANUAL

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This manual provides instructions intended for the operation of Lambda power supplies, and is not to be reproduced without the written consent of Lambda Electronics Corp. All information contained herein applies to metered, non-metered, and chassis-mounting models unless otherwise specified.

LAMBDA ELECTRONICS CORP. MELVILLE, L. I., N. Y.
MAIN PLANT TELEPHONE: 516 MYrtle 4-4200

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SPECIFICATIONS AND FEATURES

Specifications apply for the non-metered LH 118, metered LH 118FM and chassis-mounting LH 118S models.

DC OUTPUT--Voltage regulated for line and load

Voltage Range.....0-10 volts DC

Multi-Current Ranges.....Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range

Ambient Temperature.....	30°C	50°C	60°C	71°C
Current Range.....	0-4.0A	0-3.5A	0-2.9A	0-2.3A

REGULATED VOLTAGE OUTPUT

Regulation (line).....Less than 0.015 percent or 1.0 millivolt, whichever is greater for input variations from 105-135 or 135-105 volts AC

Regulation (load).....Less than 0.015 percent or 1.0 millivolt, whichever is greater for load variations from 0 to full load or full load to 0

Transient Response (line).....Output voltage is constant within regulation specifications for any 15-volt line voltage change within 105-135 volts AC

Transient Response (load).....Output voltage is constant within 50 millivolts for load changes full load to 0, within 50 microseconds after application; and is constant within 10 millivolts for load changes from 0 to full load or full load to 10% of load, within 50 microseconds after application

Remote Programming Constant...200 ohms/volt output

Internal Impedance.....Less than .375 milliohms DC to 400 cycles

Ripple and Noise.....Less than 250 microvolts rms; 1 millivolt peak to peak with either positive or negative terminal grounded

Temperature Coefficient.....Output change in voltage less than 0.015%/°C

DC OUTPUT--Current regulated for line and load; Automatic Crossover with voltage limit

Multi-Current Ranges.....Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range

Ambient Temperature..	30°C	50°C	60°C	71°C
Current Range.....	0.80-4.0A	0.80-3.5A	0.80-2.9A	0.80-2.3A

Voltage Range.....0-10 volts DC, for entire current range

REGULATED CURRENT OUTPUT; AUTOMATIC CROSSOVER

Regulation (line).....Less than 15 milliamperes for input variations from 105-135 or 135-105 volts AC

Regulation (load).....Less than 15 milliamperes for load voltage changes from 0 to 10 or 10 to 0 volts DC

Ripple and Noise.....Less than 3 ma at 55-480 cps; Less than 6 ma at 45-55 cps; both with either neg. or pos. terminal grounded

DC OUTPUT--Current regulated for line and load; Barrier strip reconnection for Precision Current Regulated Output with no voltage limiting

Multi-Current Ranges.....Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range

Ambient Temperature..	30°C	50°C	60°C	71°C
Current Range.....	0.20-4.0A	0.17-3.5A	0.14-2.9A	0.12-2.3A

Voltage Range.....0-10 volts DC, for entire current range

REGULATED CURRENT OUTPUT; PRECISION CURRENT REGULATED

Regulation (line).....Less than 0.05% or 0.5 milliampere, whichever is greater, for input variation of 105-135 or 135-105 volts AC

Regulation (load).....Less than 0.05% or 0.5 milliampere, whichever is greater, for load changes from 0-10 or 10-0 volts DC

Ripple and Noise.....Less than 1.0 ma at 55-480 cps; Less than 2.0 ma at 45-55 cps; both with either neg. or pos. terminal grounded

Remote Programming.....100 ohms, 2-watt resistance for maximum rated current; adjustable over range by decreasing resistance

AC INPUT--105-135 volts AC at 45-480 cps; 140 watts*

*With output loaded to full 30°C rating and input voltage 135 volts AC

OVERLOAD PROTECTION

Thermal.....Thermostat, resets automatically when over-temperature condition is eliminated

Electrical

External.....Adjustable, automatic, electronic current-limiting circuit, settable to 105 percent of rated current; limits output current to preset limit for protection of load and power supply when external overloads and direct shorts occur

Internal.....Fuse provides protection against internal circuit failure

INPUT AND OUTPUT CONNECTIONS--Heavy duty terminal block on rear of chassis with 5-foot, 3-wire detachable line cord for all models; five-way binding posts provide for additional positive (+), ground, and negative (-) DC output connections on front panel of FM models

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE--Continuous duty from 0°C to 71°C ambient with corresponding load current ratings for all modes of operation

STORAGE TEMPERATURE-- -55°C to +85°C
(non-operating)

METERS--Voltmeter and ammeter on metered (FM) models

CONTROLS

DC output controls.....Coarse and fine voltage controls and current control permit adjustment of DC output; located on front panel of all models

Test Jacks (+) (-).....Test jacks for non-metered model permit checking DC output with external meters

Remote Sensing.....Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation

Power.....Panel mounted switch and indicator light for all units except models with suffix (S)

PHYSICAL DATA

Size.....5-3/16"H x 4-3/16"W x 15-1/2"D (LH 118, LH 118FM)
4-5/16"H x 3-13/16"W x 15-1/2"D (LH 118S)

Weight.....14 lbs. net; 18 lbs. shipping wt.

Panel Finish.....Brushed aluminum clear anodized panels with grey inlay (standard); special finishes available to customer's specifications at moderate surcharge

MOUNTING:

Laboratory bench, table top...LH 118, LH 118FM

Chassis Mounted.....LH 118S

NOTE: Bumpers secured to the base of LH 118S units permit circulation of air through the unit. Do not remove bumpers unless the chassis-mounting is provided with a cutout to permit free-flow of air through the unit.

Standard 19" rack.....LH 118, LH 118FM; used with rack adapters: LRA-1 (slide accomodation provided)
LRA-2 (conventional mount)
See figure 18.

THEORY OF OPERATION

GENERAL

The Lambda power supply circuitry consists of an AC input circuit and transformer; a reference supply circuit consisting of an auxiliary rectifier and filter, zener diode pre-regulator, reference element and series regulator; a main regulator circuit consisting of the main rectifier and filter, a series regulator, two emitter follower drivers, a current limit amplifier, a voltage amplifier, the complementary differential amplifier circuit, and an output sensing circuit.

The circuit arrangement is shown in block diagram form in figure 14. The circuitry is discussed with reference to the block diagram and the schematic diagram.

FUNCTIONAL DESCRIPTION

Single phase input power is applied to transformer T1 through the input circuit containing thermostat S2 and fuse F1, which protect the supply against overheating and internal faults.

The main rectifier, a full-wave bridge rectifier, comprised of diodes CR14-17, provides the power which is filtered by capacitor C12 and then regulated via a series regulator and delivered to the output. The full-wave auxiliary rectifier CR10 and CR11, provides voltage filtered by capacitor C8 for reference series regulator Q6 and reference element Q5 of the reference supply as well as for pre-regulator CR8 and CR9. The reference supply output provides a regulated, temperature compensated reference voltage which is used to determine the output voltage of the unit. Cascade connected pre-regulator CR8, CR9, R24 and R23, provides stabilized bias voltage for current limit amplifier Q4, voltage amplifier Q3, "OR" gate CR4 and CR3, and for complementary differential amplifier Q1 and Q2.

Reference element Q5 contains a zener diode and transistor in one unit which act to reduce the effect of temperature changes and to provide a stable reference voltage for series regulator Q6.

Constant voltage or constant current crossover circuit operation is determined by changes in the load. A change in the load is sensed by sensing divider R5, R4, CR2 and R1A, B, which has a fixed current flowing in the divider elements as determined by the setting of calibration control R5. This variation causes a change to Q1 input of the complementary differential amplifier, which compares it with the reference voltage through the sensing divider, causing an error signal at the output of Q2. Simultaneously current limit amplifier Q4 samples the load current through current sensing resistor R43. When the current reaches a preset limit, Q4 will generate an error signal.

The error outputs from Q2 and Q4 are fed through "OR" gate CR3, CR4 to voltage amplifier Q3, and one signal is amplified by Q3 and emitter followers Q8 and Q9. The amplified signal from the emitter followers determines the impedance value of series regulator Q10, Q11 which acts as a varying impedance in series with the output. These power transistors function as the active series regulating element.

Under constant voltage operation Q4 is in saturation, CR3 conducts and CR4 in the "OR" gate is turned off, and all of the current in R9 flows through Q4. When load current increases, the voltage drop across current sensing resistor R43 increases, biasing Q4 toward cut-off. When Q4 cuts off, CR4 is forward biased and conducts while CR3 ceases to conduct. The signal is amplified via voltage amplifier Q3 and emitter followers Q8 and Q9, increasing the impedance of series regulator Q10, Q11, causing the output voltage to decrease toward zero and the unit to function at the fixed current limit.

Voltage amplifier Q3 operates at all times from the output of "OR" gate CR3, CR4, its action depending upon which signal the "OR" gate conducts. When Q4 is turned off due to an excessive load, Q3 will saturate, causing main series regulator Q10, and Q11 to turn off. When load current limit is not reached or exceeded, Q4 is in saturation and Q3 will operate with the error signal derived from Q2 of the complementary differential amplifier, causing the series regulator to change the output voltage for the preset voltage limit.

When connected for precision current operation, the complementary differential amplifier is referenced to the current sensing resistor, with a fixed current flowing from the sensing divider through potentiometer R1A, B. Any change in load will cause an error signal in the complementary differential amplifier and the circuit functions as explained previously.

OPERATING INSTRUCTIONS

CONTROLS, INSTRUMENTS AND FUSES

POWER ON Switch. The POWER ON switch, located on the front panel, controls application of input power to the supply. When the switch is in the ON position, the red POWER ON indicator glows.

OUTPUT VOLTAGE Control. The OUTPUT VOLTAGE control is a dual control consisting of a coarse adjustment potentiometer, which varies the DC voltage over a range of 0-9 volts and a fine adjustment potentiometer, which varies the DC voltage over a one-volt range. Clockwise rotation results in increasing voltage. The total DC voltage output for voltage regulated operation, is equal to the sum of each shaft setting; for current regulated operation the maximum voltage limit is equal to the sum of each shaft setting. The control is located on the front panel of all units.

CURRENT LIMITER Control. This potentiometer varies the maximum DC current over the rated *current range and, for current or voltage regulated operation, limits the DC current output to the setting on the control. Clockwise rotation results in increasing current. This control is located on the front panel.

*Operation for output current below rated limits can result in no output or no regulation.

Output Voltage Meter. A 0-10 volt DC voltmeter monitors the voltage at the output terminals of metered (FM) units.

Output Current Meter. A 0-5.0 ampere DC ammeter monitors the load output current of metered (FM) units.

Fuse. Fuse F1, internally located, is a 3 ampere, 3AG "SLO-BLO" fuse which functions in the AC input circuit.

Connection Terminals. Make all connections to the supply at the terminal block on the rear of the supply. On FM suffixed models, DC output connections can also be made at the five-way binding posts located on the front panel. Apply input power through the line cord or directly to terminals 1 and 2 if the line cord is removed. Always connect the ungrounded (hot) power lead to terminal 1.

The supply positive terminal is brought out to terminal 6. The supply negative terminal is brought out to terminal 4. Recommended wiring of the power supply to the load and selection of wiring is shown in figures 1 through 13. Selection of proper wiring is made on the basis of load requirements. Make all performance checks and measurements of current or voltage at the rear output terminals. Connect measuring devices directly to terminals or use the shortest leads possible.

GROUND CONNECTIONS

The Lambda power supply can be operated either with negative or positive output terminal grounded or with no terminal grounded. Both positive and negative ground connections are shown in the diagrams for all suggested output connections illustrated in this manual.

> NOTE: When operating the supply with neither terminal grounded, high impedance leakage resistance and capacitance paths can exist between the power supply circuitry and chassis ground.

BASIC MODES OF OPERATION

This power supply is designed to operate as a constant voltage source or as a constant current source. Except when used for a precision constant current source, automatic crossover to either mode of operation occurs when load conditions change as follows:

Constant Voltage. The power supply will function as a constant voltage source while the load current does not equal the current value, I_{LIM}, set by the CURRENT LIMITER control. When load current $I_L = \frac{V}{R_L} = I_{LIM}$, the supply will cross over automatically and will operate as a constant current source. Further decrease in value of load resistance R_L results in decrease of voltage across the load while current remains regulated to I_{LIM}.

Constant Current (Automatic Crossover). The power supply will function as a constant current source while the load voltage V_L does not equal the voltage value set by the OUTPUT VOLTAGE control. When load voltage VL equals the value set by the OUTPUT VOLTAGE control, the supply will automatically cross over and operate as a constant voltage source.

Constant Current (Precision). The power supply will function within rated specifications as a conventional constant current source without automatic crossover. When load voltage demand exceeds the rated voltage of the power supply, the unit output current regulation will not be within specification.

SUPPLY-LOAD CONNECTIONS

> NOTE: Refer to DETAILED OPERATING PROCEDURES for step-by-step instructions for operation of power supply.

CONNECTIONS FOR OPERATION AS A CONSTANT VOLTAGE SOURCE

The output impedance, regulation, and transient response of the power supply at the load may change when using the supply as a constant voltage source and connecting leads of practical length are used. To minimize the effect of the output leads on these characteristics, remote sensing is used. Recommended types of supply load connections with local or remote sensing are described in the following paragraphs.

Refer to figures 1 and 2 to determine voltage drop for particular cable length, wire size and current conditions. Lead lengths must be measured from supply terminals to load terminals as shown in figure 3.

Two-Wire Connection, Figure 4. The two-wire connection, with local sensing, is the connection suitable for application with relatively constant load where extremely close load regulation and fast transient response over full-rated current excursion are not required at the load.

Improved Two-Wire Connection, Figure 5. The improved two-wire connection, with local sensing, is suitable for applications where excessively long connecting leads are not used. Using multiple paralleled leads in this type of connection reduces the supply-load lead voltage drop and permits improved regulation and transient response.

Four-Wire Connection, Figure 6. The four-wire connection with remote sensing, provides complete compensation for the DC voltage drops in the connecting cables. Compensation for lead drop is also valid for gradual changes of load current.

Programmed Voltage Connections, Using External Resistor, Figure 7. Discrete voltage steps can be programmed with a resistance voltage divider valued at 200 ohms/volt output and a shorting-type switch as shown in figure 7. When continuous voltage variations are required, use variable resistor with the same 200 ohms/volt ratio in place of the resistive voltage divider and shorting-type switch. Use a low temperature coefficient resistor to assure most stable operation.

As shown in figure 7, voltages can be programmed utilizing either local or remote sensing connections, as desired.

Programmed Voltage Connections Using Programming Voltage, Figure 8. The power supply voltage output can be programmed with an externally connected programming power supply.

The output voltage of the programmed supply will maintain a one-to-one ratio with the voltage of the programming supply.

CONNECTIONS FOR OPERATION AS A CONSTANT CURRENT SOURCE

Automatic Crossover Constant Current Connections, Figure 4. Figure 4 shows the connections which are used when operating the power supply as a constant current source with automatic crossover, using local setting of current control.*

*Setting control for output currents below rated limits can result in no output or no regulation.

In this mode of operation, when the load voltage increases, due to changing load resistance, to the limit of the OUTPUT VOLTAGE control setting, the power supply crossover circuit will cause the unit to operate as a constant voltage supply.

Precision Regulated Constant Current Connections, Figure 9. Figure 9 shows the connections which are used when operating the power supply as a precision constant current source, using local setting of current control.

In this mode of operation, the power supply functions as a conventional constant current supply with crossover circuit inoperative. The load voltage limit is fixed to the maximum voltage rating of the power supply.

Programmed Precision Regulated Current Connections, Figure 10. To provide discrete current steps from 5% to 100% of rated current, use any combination of separate 2-watt resistors totalling 100 ohms together with a shorting-type switch connected as shown in figure 10. Use resistors with low temperature coefficients to assure most stable operation.

When continuous current variations are required, use a 100 ohm, 2-watt variable resistor in place of the separate resistors and shorting-type switch.

CONNECTIONS FOR SERIES OPERATION

The voltage capability of LH power supplies can be extended by series operation of two LH power supplies of equal* voltage ratings. A maximum of 200 volts can be connected between either the +DC or -DC terminal and chassis ground.

*For applications using supplies of unequal ratings, consult factory for details of operation.

The two units are shown connected for series operation in figures 11 and 12. Figure 11 shows the series connection diagram which would be suitable for use in all applications where exact one-to-one voltage tracking of the "master" (M) unit by the "slave" (S) unit is not required. The slight offset in tracking is easily compensated for by adjusting the OUTPUT VOLTAGE controls on the (S) unit.

Figure 12 shows the series connection diagram suitable for applications where exact one-to-one voltage tracking is required. In this series configuration, resistor R_{BAL} permits the (S) unit to track the (M) unit on an exact one-to-one basis, thereby eliminating the possibility of an offset voltage existing between the two units.

Resistor R_{BAL} should be a one-watt, 10-20 kilohm resistor. This value would permit wide-range compensation for manufacturing differences inherent in the components used in each unit. Resistors R_S and R_M function in the voltage sensing circuits of both units, enabling the (S) unit to reference its output voltage to that of the (M) unit. In figure 11, R_S performs a similar function. Capacitor C_S, used to eliminate stray AC pickup, is rated at 2.5 mfd, 100 V.

For either series mode of operation, select R_S and R_M on the basis of 200 ohms per volt of (M) unit output voltage. R_S must equal R_M.

Diodes CR_M and CR_S, which protect the units against reverse voltage, must be capable of withstanding the maximum rated current of the (M) unit.

Both methods permit operation for either constant voltage or constant current with automatic crossover to either mode of operation whenever the respective limiting operating current or voltage is reached. As shown in figures 11 and 12, each method permits connection for either local or remote sensing.

CONNECTIONS FOR PARALLEL OPERATION

The current capability of LH power supplies can be extended by parallel operation of two LH power supplies of equal* voltage capacities. The two units are shown connected for parallel operation in figure 13. One power supply designated the "master" or (M) unit controls its own output as well as the output of the second power supply, designated the "slave" or (S) unit.

*For applications using supplies of unequal voltage ratings, consult factory for details of operation.

Unit (S) operates to regulate its current in a ratio to that of the (M) unit by comparing the current in its internal sampling resistor with that current sampled by the master internal sampling resistor. When power supplies of unequal current capacities are parallel connected the division of current supplied will be approximately equal to the ratio of the current ratings of the supplies.

Parallel connected units can be operated for constant voltage with local sensing as well as for constant current with automatic crossover. When operating for constant voltage, the (M) unit can automatically crossover into constant current operation.

DETAILED OPERATING PROCEDURES

SAFETY NOTICE

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT. OBSERVE THE USUAL SAFETY PRECAUTIONS WHEN OPERATING OR SERVICING THE EQUIPMENT TO AVOID SHOCK OR INJURY.

CONSTANT VOLTAGE OPERATION, ADJUSTABLE CURRENT LIMIT

1. Remove AC power input to the supply and place POWER ON switch in OFF position before connecting load to the supply.

2. Determine load requirements, select wire from figures 1-3 and choose desired type of supply-load connection from figures 4-6.

3. Connect supply to load as shown on the selected connection diagram.

NOTE: When shipped from the factory, the supply is ready for use as a constant current source with automatic crossover or as a local-sensing constant voltage source. Jumpers are connected at the factory as shown in figure 4. Take care to remove the appropriate jumpers for load requirements that need different supply-load connections. Refer to the appropriate connection diagram.

4. Turn OUTPUT VOLTAGE control knobs to the desired voltage setting.

5. When current to the load must be limited to an intermediate value within the current rating of the supply, turn the CURRENT LIMITER control to the desired current limit setting. If no intermediate current limit is required, turn the control CW to the position for full current rating for the maximum ambient temperature of operation. Refer to section on specifications.

6. Apply AC power to the supply.

7. Place POWER ON-OFF switch in ON position and check that red POWER ON indicator is lit.

8. Check that output current and output voltage meters indicate desired values; as required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 6 and 4, or at front panel test jacks (+) and (-); for remote sensing connections, check at the load terminations of sensing leads on terminals 3 and 7.

9. Power supply is now in proper operation.

PROGRAMMED CONSTANT VOLTAGE OPERATION, ADJUSTABLE CURRENT LIMIT

1. Remove AC power input to the supply and place POWER ON switch in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size and length from figures 1, 2 and 3 and choose desired type of supply-load connection from figures 7 or 8. Refer to paragraph on Programmed Voltage Connections.

3. Connect supply to load as shown on the selected connection diagram. As shown in figure 7, take care to use a shorting-type switch for the external programming control when several voltages are desired and the programming voltage method is not used.

4. Turn OUTPUT VOLTAGE control knobs to the extreme CCW position. Adjust external programming voltage control to desired voltage setting.

5. When current to the load must be limited to an intermediate value within the current rating of the supply, turn the CURRENT LIMITER knob to the desired current limit setting. If no intermediate current limit is desired, turn the control CW to the position for full rated current for the ambient temperature of operation. Refer to section on specifications.

6. Apply AC power to the supply.

7. Place POWER ON switch in ON position and check that red POWER ON indicator is lit.

8. Check that output current and output voltage meters indicate desired values; as required, adjust CURRENT LIMITER knob and external programming voltage control to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6, or at front panel test jacks (+) and (-); for remote sensing connections check at the load terminations of sensing leads on terminals 3 and 7.

9. Power supply is now operating properly.

CONSTANT CURRENT OPERATION WITH CROSSOVER, ADJUSTABLE VOLTAGE LIMIT

1. Remove AC power input to the supply and place POWER ON switch in OFF position before connecting load to the supply.

2. Determine load requirements and connect load to the supply as shown in figure 4.

3. Turn the CURRENT LIMITER knob to the desired current setting.

4. When load voltage must be limited to an intermediate value within the voltage rating of the supply, turn OUTPUT VOLTAGE control knobs to the desired voltage limit setting. If no intermediate voltage limit, within rating of supply is desired, turn controls to the full CW position to obtain voltage limit at maximum voltage rating of the supply.

5. Apply AC power to the supply.

6. Place POWER ON switch in ON position and check that red POWER ON indicator is lit.

7. Check that output current and output voltage meters indicate desired values; adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control as required to obtain correct indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6, or at front panel test jacks (+) and (-).

8. Power supply is now in proper operation.

PRECISION REGULATED CONSTANT CURRENT OPERATION

1. Remove AC power input to the supply and place POWER ON switch in OFF position before connecting load to the supply.

2. Determine load requirements and connect load to the supply as shown in figure 9.

3. Turn the CURRENT LIMITER knob to the maximum desired current setting.

4. Turn both OUTPUT VOLTAGE control knobs to extreme CCW position.

5. Apply AC power to the supply. Place POWER ON switch in ON position and check that red POWER ON indicator is lit.

6. Turn fine OUTPUT VOLTAGE control knob CW until the desired current setting as indicated by output current meter is reached.

7. Check that output current meter indicates desired value and that output voltage meter does not indicate OFF scale. Adjust fine OUTPUT VOLTAGE control knob as required, to obtain correct indication. For non-metered models use extremely connected meters and check that correct meter indications exist at output terminals 4 and 9.

8. Power supply is now in proper operation.

PROGRAMMED PRECISION REGULATED CONSTANT CURRENT OPERATION

1. Remove AC power input to the supply and place the POWER ON switch in OFF position before connecting load to the supply.

2. Determine load requirements. Connect load to the supply as shown in figure 10. Refer to paragraph on Programmed Current Connections.

3. Turn the CURRENT LIMITER knob to the maximum desired setting.

4. Turn OUTPUT VOLTAGE control knobs to extreme CCW position.

5. Apply AC power to the supply. Place POWER ON switch in ON position and check that red POWER ON indicator is lit.

6. Turn fine OUTPUT VOLTAGE control knob CW until the desired current setting is reached, as indicated by output current meter.

7. Check that output current meter indicates desired value and that output voltage meter does not indicate OFF scale. As required, adjust external current programming control to obtain correct indication. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 9.

8. Power supply is now in proper operation.

SERIES CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Remove AC power input to the "slave" (S) and "master" (M) units and place POWER ON switches in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1-3 and choose correct type of series supply-load connections from figures 11 and 12. Refer to paragraph on CONNECTIONS FOR SERIES OPERATION.

3. Connect supply to load as shown on the selected connection diagram. As required, select resistors R_{BAL}, R_S and R_M, and diodes CR_S and CR_M in accordance with instructions contained in CONNECTIONS FOR SERIES OPERATION.

4. Turn (M) unit OUTPUT VOLTAGE control knobs to the desired voltage setting. This setting will be approximately one-half of the combined (M) and (S) unit output voltage.

5. Turn (S) unit OUTPUT VOLTAGE control knobs and CURRENT LIMITER control to extreme CW position.

6. When current to the load must be limited to an intermediate value within current rating of the unit with lower current capacity (M unit) turn the (M) unit CURRENT LIMITER control to the desired setting. If no intermediate current limit is required, turn the control CW to the position for full current rating for the maximum ambient temperature of operation. Refer to section on specifications.

NOTE: When units of equal current rating are series connected, the (M) unit CURRENT LIMITER control must be set at a position slightly less than that of the (S) unit.

7. Apply AC power to the supplies.

8. Place POWER ON switches of both units in ON position and check that red POWER ON indicators are lit.

9. Check that output current and output voltage meters indicate desired values; total voltage is equal to sum of (S) and (M) units. As required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control of (M) unit to obtain correct indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals of the (S) and (M) units; positive (+) terminal of (M) unit and minus (-) terminal of the (S) unit are the output terminals of the series combination.

Use front panel jacks (+) of (M) unit and (-) of (S) unit to make current and voltage checks for the appropriate units. For remote sensing connection, make checks at the load terminations of sensing leads from terminals 7 of (M) unit and from R_S connection of (S) unit.

10. Power supplies are now in proper operation.

SERIES CONNECTION CONSTANT CURRENT OPERATION, WITH VOLTAGE LIMIT

1. Remove AC power input to the (S) and (M) units and place POWER ON switches in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1-3 and choose correct type of series supply-load connections from figures 11 and 12. Refer to paragraph on Connections for Series Operation.

3. Connect supply to load as shown on the selected connection diagram. As required, select resistors R_{BAL}, R_S and R_M and diodes CR_S and CR_M as instructed in Connections for Series Operation paragraph.

4. Turn (M) unit CURRENT LIMITER control to the desired setting.

NOTE: When units of equal current rating are series connected, the (M) unit CURRENT LIMITER control must be set at a position slightly less than that of the (S) unit.

5. Turn (S) unit OUTPUT VOLTAGE control knobs and CURRENT LIMITER control to extreme CW position.

6. When load voltage must be limited to an intermediate value within the voltage rating of the series combination, turn the (M) unit OUTPUT VOLTAGE control knobs to a position approximately one-half the total voltage rating for the combination.

If no intermediate voltage limit is required, turn the control to the full CW position to obtain voltage limit at the maximum combined ratings of the supplies.

7. Apply AC power to the supplies.

8. Place POWER ON switches of both units to ON position and check that red POWER ON indicators are lit.

9. Check that output current and output voltage meters indicate desired values; total voltage is the sum of (S) and (M) unit voltages. As required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control of (M) unit to obtain correct indications. For non-metered models, use externally connected meters and check that correct meter indications exist at output terminals of the (S) and (M) units; positive (+) terminal of (M) unit and minus (-) terminal of the (S) unit are the output terminals of the series combination.

Use front panel jacks (+) of (M) unit and (-) of (S) unit to make current and voltage checks for the appropriate units. For remote sensing connections make checks at the load terminations of sensing leads from terminal 7 of (M) unit and from R_S connection of (S) unit.

10. Power supplies are now in proper operation.

PARALLEL CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Remove AC power input to each supply and place POWER ON switch on both (M) and (S) units in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1-3 in the manual. Refer to paragraph on Connections for Parallel Operation.

3. Connect supplies to load as shown in connection diagram, figure 13.

NOTE: When shipped from the factory, each supply is ready for use as a constant current source or as a local-sensing constant voltage source. Jumpers are connected at the factory. Take care to remove the appropriate jumpers for load requirements that need different supply-load connections. Refer to the appropriate connection diagram.

4. Turn OUTPUT VOLTAGE control knobs on the (M) unit to the desired voltage setting, and turn the controls on the (S) unit to fully CCW position.

5. When current to the load must be limited to an intermediate point, turn the CURRENT LIMITER control on both the (M) and (S) units to the desired current limit setting. Set current limit control on the (M) and (S) units to the position indicating the current value to be delivered by the respective unit. If no intermediate current limit is desired, turn the control CW on both (M) and (S) units to the position for full rated current for the maximum ambient temperature of operation. Refer to section on specifications.

6. Apply AC power to each supply.

7. Place POWER ON switches on (M) and (S) units in ON position and check that red POWER ON indicators are lit.

8. Check that output current and output voltage meters on both (M) and (S) units indicate desired values; as required, adjust OUTPUT VOLTAGE control and CURRENT LIMITER control on (M) unit to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6 of the (M) unit, or at front panel jacks (+) and (-) of the (M) unit; for remote sensing connection, check at the load termination of sensing leads on terminals 3 and 7 of the (M) unit.

9. Power supplies are now in proper operation.

PARALLEL CONNECTION CONSTANT CURRENT OPERATION, WITH VOLTAGE LIMIT

1. Remove AC power input to each supply and place POWER ON switch on both (M) and (S) units in OFF position before connecting load to the supplies.

2. Determine load requirements and connect load to the supplies as shown in figure 13. Refer to paragraph on Connections for Parallel Operation.

3. Turn the CURRENT LIMITER knob on (M) unit to the desired current setting. Turn OUTPUT VOLTAGE control knobs on the (S) unit to full CCW position.

NOTE: When setting the CURRENT LIMITER knob on the (M) and (S) units take care to set the control so that each unit indicates the proportion of total current that the unit must supply.

4. When load voltage must be limited, turn OUTPUT VOLTAGE control knobs on the (M) unit to the desired voltage limit setting. If no voltage limit, within rating of the supply is desired, turn controls on the (M) unit to the full CW position.

5. Apply AC power to each supply.

6. Place POWER ON switches on (M) and (S) units in ON position and check that red POWER ON indicators are lit.

7. Check that output current and output voltage meters on both units indicate desired values; adjust OUTPUT VOLTAGE control and CURRENT LIMITER control, as required, to obtain correct indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6 of the (M) unit, or at front panel jacks (+) and (-) of the (M) unit.

8. Power supply is now in proper operation.

OPERATION AFTER PROTECTIVE DEVICE SHUTDOWN

Thermostat Shutdown

The thermostat opens the input circuit only when the temperatures of the transistor heat radiator exceeds a maximum safe value. The thermostat will automatically reset when the temperature of the radiator decreases to safe operating value. After eliminating the cause(s) for overheating and allowing time for the power supply to cool to a proper temperature, resume operation of the supply. Refer to appropriate operation paragraph in DETAILED OPERATING PROCEDURES.

Fuse Shutdown

Internal component failure is prevented by fuses which protect the components from damage caused by excessive currents. Fuses will blow when the maximum rated current value for the fuse is exceeded. Fatigue failure of fuses can occur when mechanical vibrations from the installation combine with thermally induced stresses to weaken the fuse metal. Many fuse failures are caused by a temporary condition, and replacing the blown fuse will make the fuse protected circuit operative.

MAINTENANCE

GENERAL

This section describes trouble analysis routine, replacement procedures, calibration and test procedures that are useful for servicing the Lambda power supply. A trouble chart is provided as an aid for the troubleshooter. Refer to the section on specifications and features for the minimum performance standards.

TROUBLE ANALYSIS

Whenever trouble occurs, systematically check all fuses, primary power lines, external circuit elements, and external wiring for malfunction before trouble shooting the equipment. Failures and malfunctions often can be traced to simple causes such as improper jumpers and supply-load connections or fuse failure due to metal fatigue.

Use the electrical schematic diagram and block diagram, figure 14, as an aid to locating trouble causes. The schematic diagram contains various circuit voltages that are averages for normal operation. Measure these voltages using the conditions for measurement specified on the schematic diagram. Use measuring probes carefully to avoid causing short circuits and damaging circuit components.

CHECKING TRANSISTORS AND CAPACITORS

Check transistors with an instrument that has a highly limited current capability. Observe proper polarity for PNP or NPN to avoid error in measurement. The forward transistor resistance is low but never ZERO; backward resistance is always higher than the forward resistance. Resistance between transistor collector and emitter, in either direction, varies with temperature; variation is greater for the forward direction resistance.

For good transistors, the forward resistance for any junction is always greater than zero.

Do not assume trouble is eliminated when only one part is replaced. This is especially true when one transistor fails, causing other transistors to fail. Replacing only one transistor and turning power on, before checking for additional defective components could damage the replaced component.

When soldering semi-conductor devices, hold the lead being soldered with a pair of pliers placed between the component and the solder joint to provide an effective heat sink.

NOTE: The leakage resistance obtained from a simple resistance check of a capacitor is not always an indication of a faulty capacitor. In all cases the capacitors are shunted with resistances, some of which have low values. Only a dead short is a true indication of a shorted capacitor.

PRINTED CIRCUIT BOARD MAINTENANCE TECHNIQUES

1. If foil is intact but not covered with solder it is a good contact. Do not attempt to cover with solder.

2. Voltage measurements can be made from either side of the board. Use a needle-point probe to penetrate to the wiring whenever a protective coating is used on the wiring. A brass probe can be soldered to an alligator clip adapted to the measuring instrument.

3. Always use a heat sink when soldering transistors.

4. Broken or damaged printed wiring is usually the result of an imperfection, strain or careless soldering. To repair small breaks, tin a short piece of hook-up wire to bridge the break, and holding the wire in place, flow solder along the length of wire so that it becomes part of the circuitry.

5. When unsoldering components from the board, flow the solder onto the soldering iron tip; never pry or force loose a part to be removed.

TROUBLE CHART

The trouble chart is intended as a guide for locating trouble causes, and is used along with the schematic diagram.

The operating conditions assumed for the trouble chart are as follows:

(a) AC power of proper voltage and frequency is present at input terminals.

(b) Either positive or negative terminal is connected to chassis ground.

(c) The power supply is connected for constant voltage with local sensing. See schematic; dotted lines indicate jumpers connected for local sensing operation.

TROUBLE CHART

Symptom	Probable Cause	Remedy
1. POWER ON lamp DS1 does not light with POWER ON switch in ON position; no output voltage	No power input; POWER ON switch S1 defective; defective fuse F1; thermostat S2 open, fuse F1 blown	Check power source, line cord and line cord plug; replace S1; replace F1; shut off unit, allow to cool and check ambient temperature
		Replace F1; if it blows immediately, check diodes CR14-17 and capacitor C12, replace as necessary
2. Unable to adjust output voltage	Damaged OUTPUT VOLTAGE controls	Check R1A and R1B for shorts and/or open, replace as necessary
	Supply operating as constant current source with cross-over at CURRENT LIMITER setting	Remove load and check for shorts and/or improper supply-load connections; refer to appropriate diagram for correct connections
3. Zero volts DC output, with POWER ON indicator lit	OUTPUT VOLTAGE controls turned fully CCW	Check OUTPUT VOLTAGE controls for proper setting and correct as necessary
	Short circuit across output of supply	Check load and load connections, correct as necessary
	Series regulator section open	Check Q10 and Q11 for open, replace as necessary
	R37 defective, open Q4, CR18, CR19	Check R37, Q4, CR18,CR19 for open, replace as necessary
	Emitter followers open	Check Q8 and Q9 for open, replace as necessary
	Current sensing resistor open	Check R43 for open, replace as necessary
	Improper reference supply operation as indicated by voltage between output terminal 7 and T.P. on fine regulator board	The reference voltage between terminal 7 and T.P. should be 7.5 to 8.5 volts if this voltage does not exist, then check Q6 for open, Q5 for short,

TROUBLE CHART (cont'd)

Symptom	Probable Cause	Remedy
(3. cont'd)		CR8 and CR9 for short or CR10 and CR11 for open; replace as necessary
4. High ripple at line frequency or twice line frequency and unregulated DC output	Series regulator transistors shorted; emitter followers shorted; voltage amplifier open	Check and replace as necessary: Q10, Q11; Q8, Q9 and Q3;
	Defective main rectifier causes ripple at twice line frequency	CR14-17 in addition to Q8-Q11 and Q3
	Line voltage too low	Check and correct AC input voltage at supply terminals
5. Same as 4, except intermittent	Foreign matter fallen into unit	Check for loose bench hardware and wire clippings that may have fallen through cover
	Emitter follower Ico resistors open or changed value causing thermal run-a-way	Check R33, R34 and R36 values and replace as necessary
6. High ripple at frequency other than line or twice line frequency	Oscillation due to defective component in filter network	Check for open C1, C2 and check for open and/or short in R13, C6 and C5, R11 network and replace defective component
7. Large spikes at output	Capacitor C19 open	Replace C19 as necessary

ADJUSTMENT OF CALIBRATION CONTROLS

Whenever parts are replaced, adjust calibration controls only when voltage and current indications are improper and do not reflect maximum ratings.

Adjust Calibration Control R5 as Follows:

1. Remove AC power input to the supply and place POWER ON switch in OFF position.

2. Unsolder wiper of R5 from resistor housing.

3. Operate the power supply for constant voltage with local sensing jumpers connected as shown in figure 4, and no external load.

4. Turn OUTPUT VOLTAGE control knobs fully clockwise and, using a DC voltmeter of one percent accuracy or better, adjust R5 to provide output voltage E_O MAX + 0.25 volts at 25°C ambient; where E_O MAX is the rated output voltage of the supply.

5. After adjustment is completed, remove AC power input to the supply and solder wiper of R5 to potentiometer housing.

Adjust Calibration Control R14 as Follows:

1. Remove AC power input to the supply and place POWER ON switch in OFF position.

2. Unsolder wiper of R14 from resistor housing.

3. Turn OUTPUT VOLTAGE control knobs and CURRENT LIMITER control fully CW.

4. Operate the power supply for constant current crossover, connected as shown in figure 4, with a short circuit across the output terminals.

5. Adjust R14 for 4.2 ampere output, using any DC ammeter of one percent accuracy or better.

6. After adjustment is completed, remove AC power input to the supply and solder wiper of R14 to potentiometer housing.

PERFORMANCE CHECKS

Checks With Constant Voltage Operation

Check the ripple and regulation of the power supply using the test connection diagram shown in figure 15. Use suggested test equipment or equivalent to obtain accurate results. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Set the differential meter, DC VTVM (John Fluke Model 801H or equivalent) to the selected power supply operating voltage. Check the power supply load regulation accuracy while switching from the load to no-load condition. Long load leads should be a twisted pair to minimize AC pick-up.

Use a Variac to vary the line voltage from 105-135 or 135-105 volts AC and check the power supply line regulation accuracy on the VTVM differential meter.

Use a VTVM, Ballantine 320 or equivalent, to measure rms ripple voltage of the power supply DC output. Use oscilloscope to measure peak-to-peak ripple voltage of the power supply DC output.

Checks With Constant Current Operation

Check the ripple or regulation of the power supply using the test connection diagram shown in figure 16 or 17. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Check the power supply load regulation accuracy while switching from the short circuit to load condition. Measure the voltage across sensing resistor Rs. Use John Fluke Model 801H or equivalent for the VTVM connected across Rs. For Rs, use a resistor having the same value as resistor R43 in the unit being tested. To obtain regulation figure, substitute values obtained into regulation formula:

$$\frac{\Delta E}{Rs} = \text{Regulation in milliamperes,}$$

where ΔE is the voltage change in millivolts and Rs is the resistance of the sensing resistor.

Use a Variac to vary the line voltage from 105-135 or 135-105 volts AC and check the power supply line regulation accuracy using VTVM and the regulation formula:

$$\frac{\Delta E}{Rs}$$

To measure rms ripple current of the power supply DC output, use a Ballantine Model 320 or equivalent meter and obtain ripple current Ir by substituting measured values into formula:

$$\frac{\text{V.A.C. rms}}{Rs} = Ir$$

SERVICE

When additional instructions are required or repair service is desired, contact the nearest office of the Lambda Electronics Corp. where trained personnel and complete facilities are ready to assist you.

Please include the power supply model and serial number together with complete details of the problem. On receipt of this information, Lambda will supply service data or advise shipping for factory repair service.

All repairs not covered by the warranty will be billed at cost and an estimate forwarded for approval before work is started.

PARTS ORDERING

Standard components and special components used in Lambda power supply can be obtained from the factory. In case of emergency, critical spare parts are available through any Lambda office.

The following information must be included when ordering parts:

1. Model number and serial number of power supply and purchase date.
2. Lambda part number.
3. Description of part together with circuit designation.
4. If part is not an electronic part, or is not listed, provide a description, function, and location of the part.

MDJ-00-201

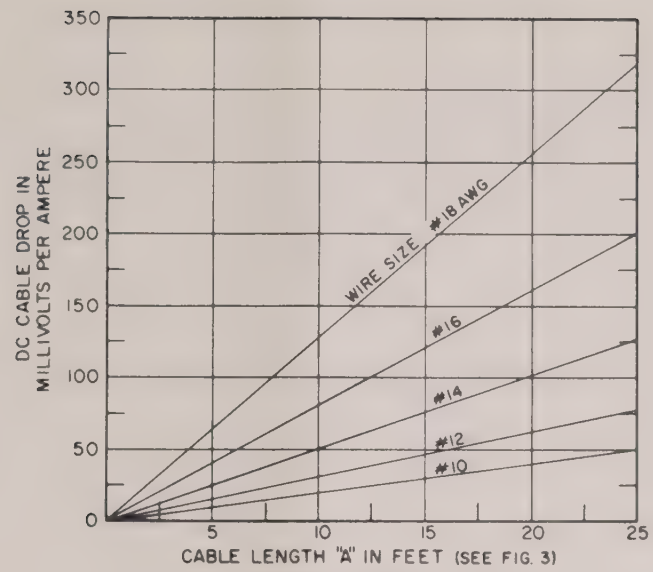


FIG.1. 2-WIRE CONNECTION (SEE FIG. 4)

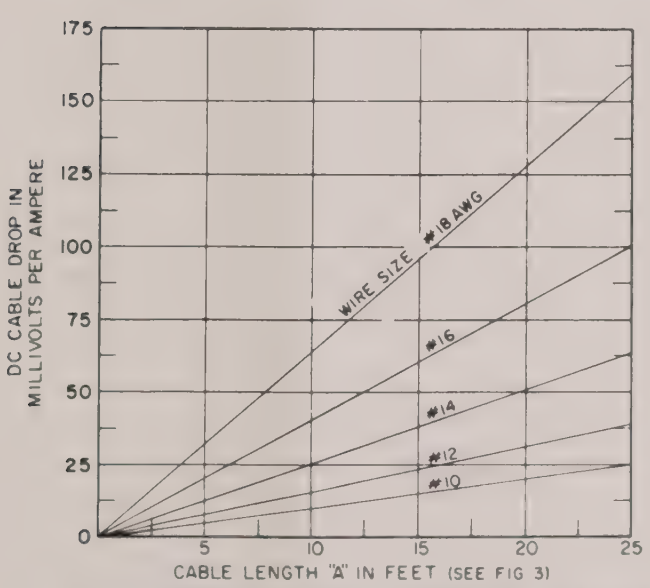


FIG. 2. IMPROVED 2-WIRE CONNECTION (SEE FIG.5)

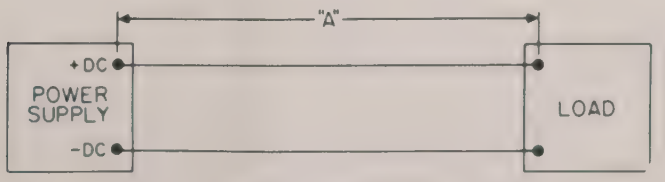
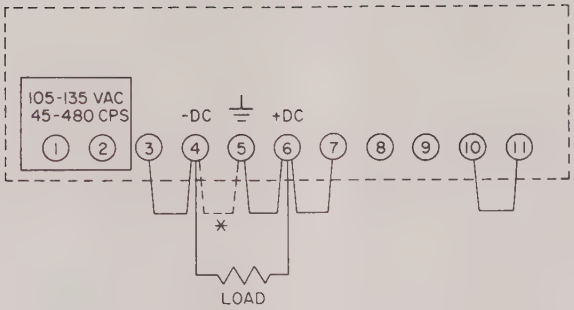
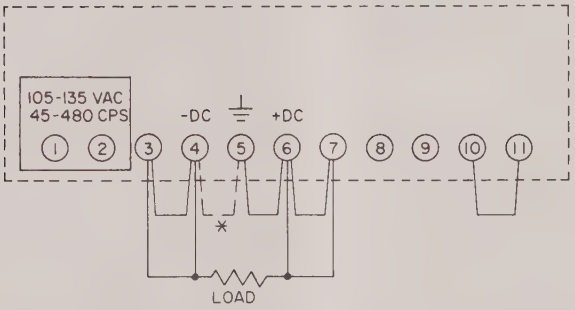


FIG. 3. CABLE LENGTH "A" IN FEET



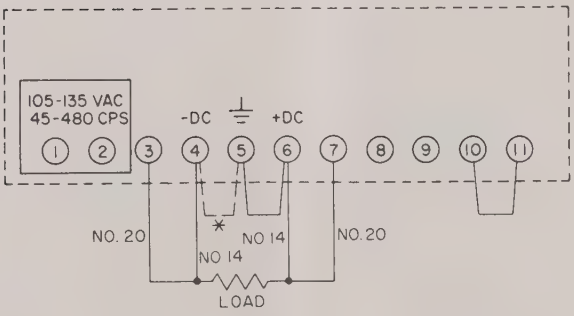
NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 4. TWO-WIRE CONNECTION



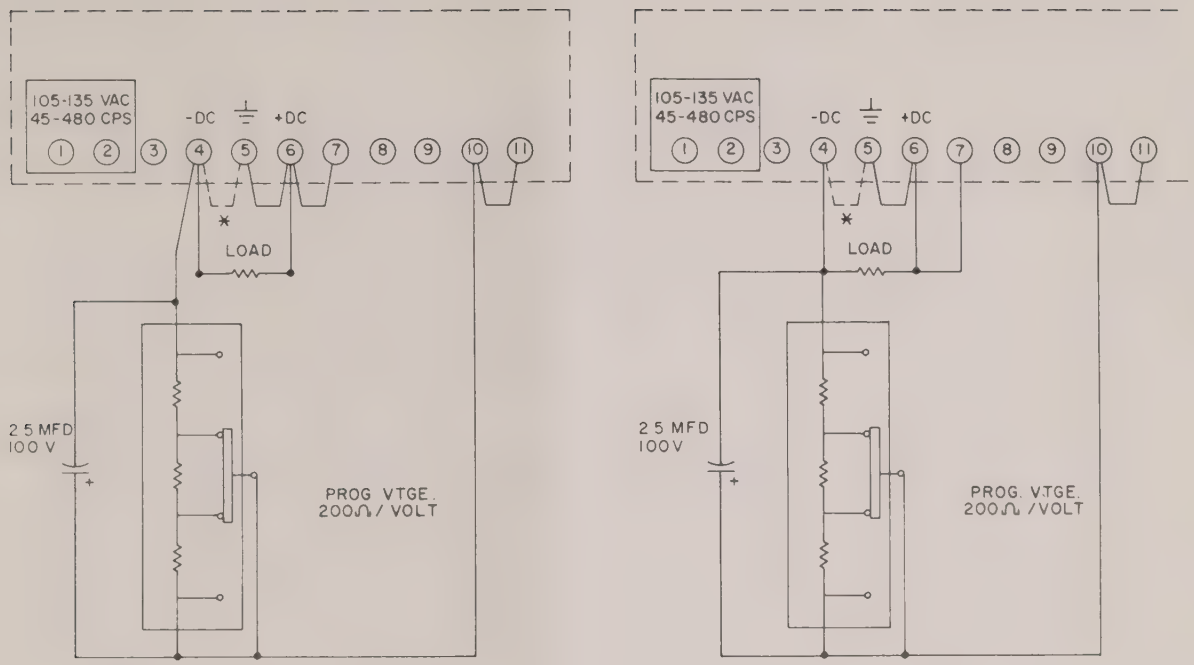
NOTE.
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 5. IMPROVED TWO-WIRE CONNECTION



NOTE.
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 6. FOUR-WIRE CONNECTION

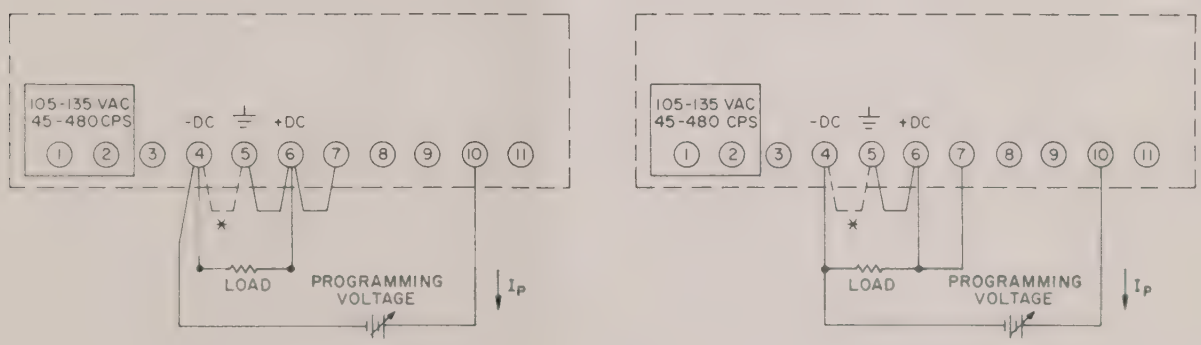


(A) LOCAL SENSING

(B) REMOTE SENSING

NOTE
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 7. PROGRAMMED VOLTAGE, WITH EXTERNAL RESISTOR

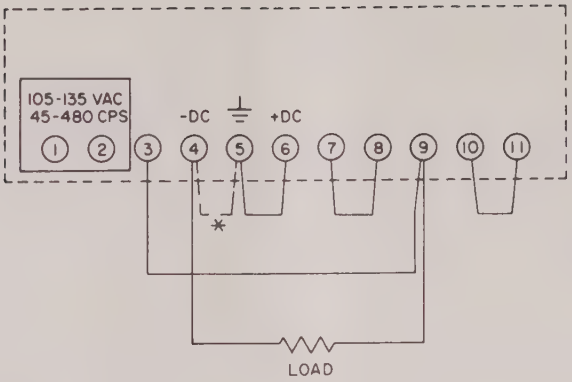


(A) LOCAL SENSING

(B) REMOTE SENSING

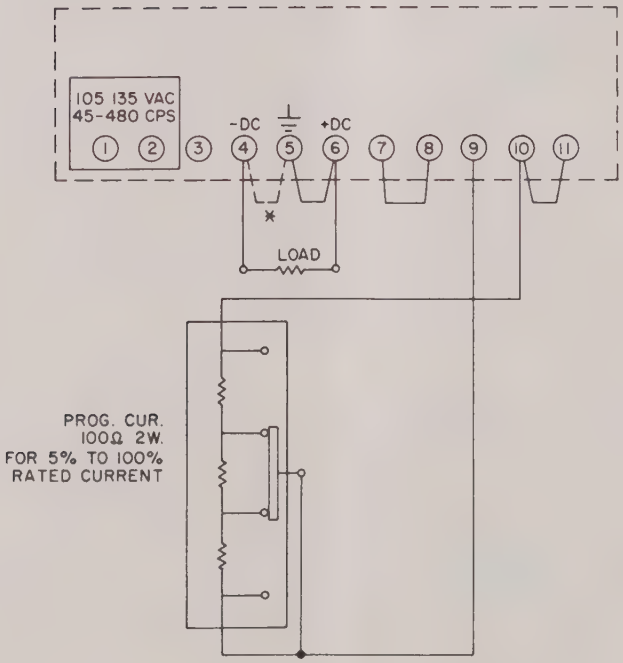
NOTE
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5

FIGURE 8. PROGRAMMED VOLTAGE, WITH EXTERNAL PROGRAMMING VOLTAGE SOURCE



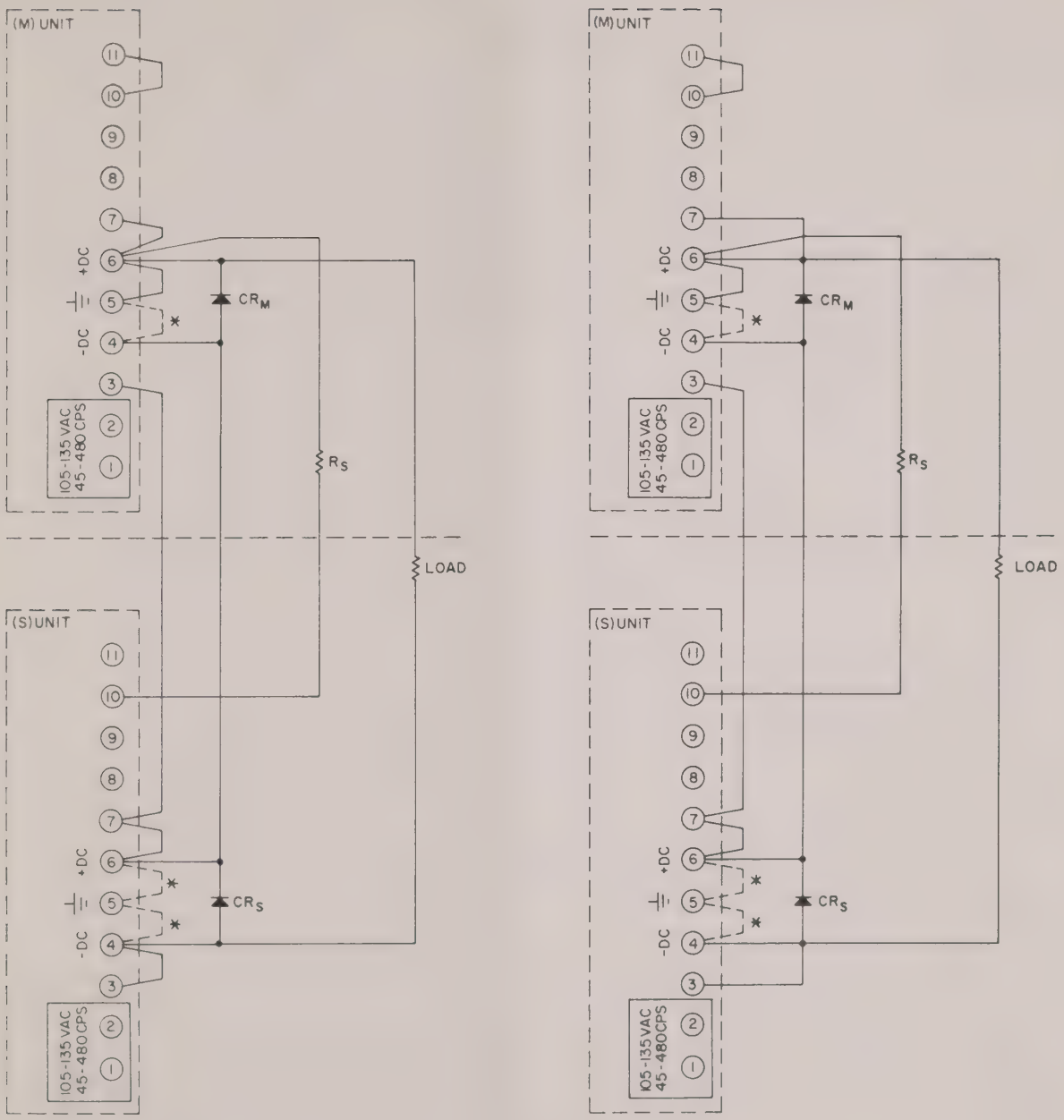
NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPERS FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 9. PRECISION CONSTANT CURRENT



NOTE.
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5

FIGURE 10. PROGRAMMED PRECISION CONSTANT CURRENT



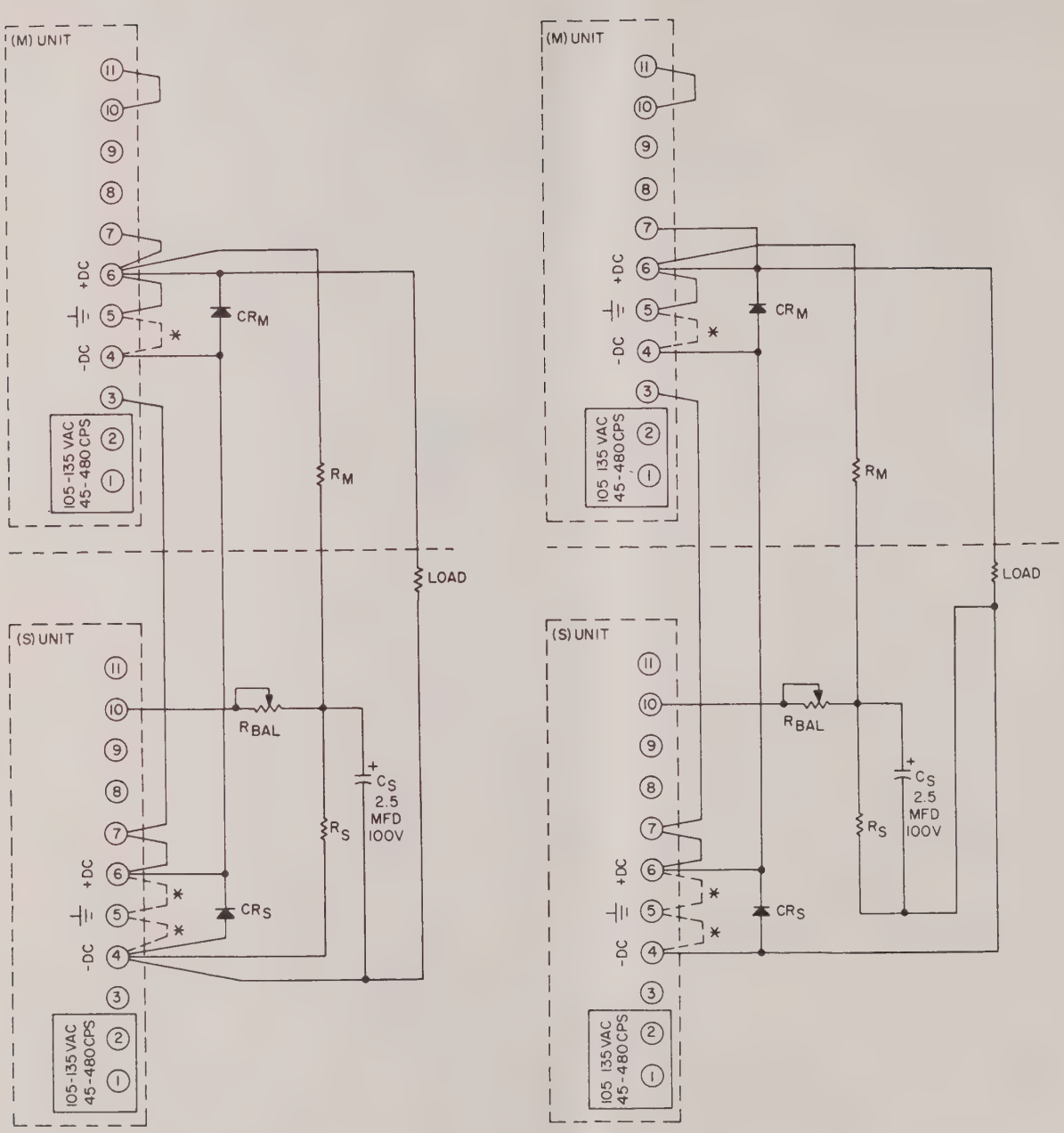
(A) LOCAL SENSING

(B) REMOTE SENSING

NOTE.

* MAKE ONLY ONE GROUND CONNECTION FOR THE SERIES COMBINATION; TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FORM TERMINALS 5 AND 6 ON (M) UNIT AND CONNECT ANY ONE OF THE OTHER JUMPERS AS SHOWN IN DOTTED LINE.

FIGURE 11. SERIES CONNECTION

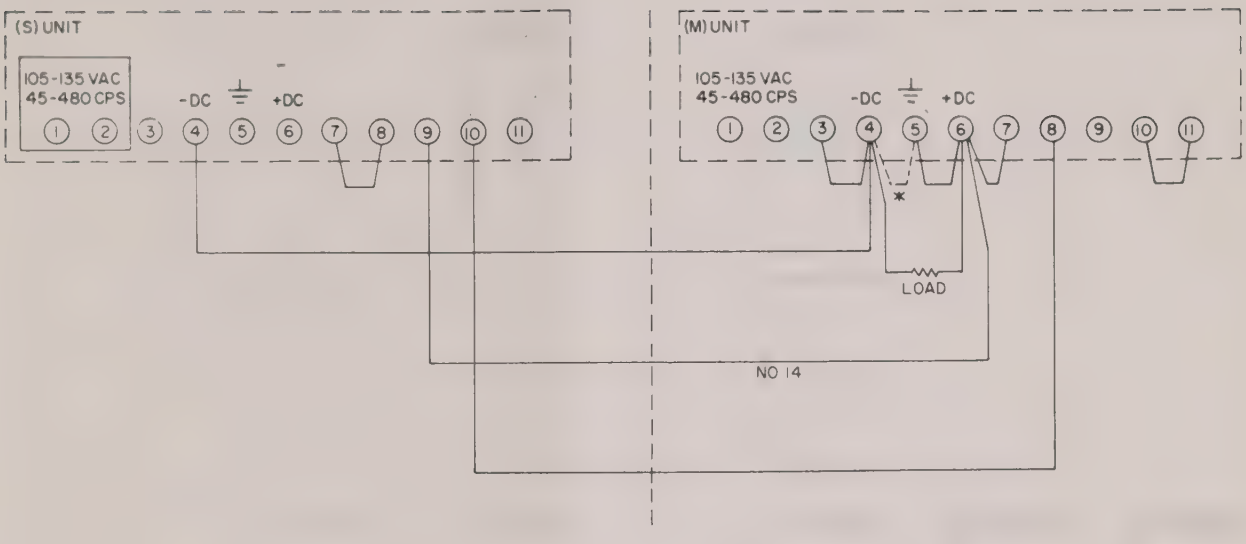


(A) LOCAL SENSING

(B) REMOTE SENSING

NOTE:
* MAKE ONLY ONE GROUND CONNECTION FOR THE SERIES COMBINATION; TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FROM TERMINALS 5 AND 6 ON (M) UNIT AND CONNECT ANY ONE OF THE OTHER JUMPERS AS SHOWN IN DOTTED LINE.

FIGURE 12. ALTERNATE SERIES CONNECTION



NOTE.
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 13 PARALLEL CONNECTION, LOCAL SENSING

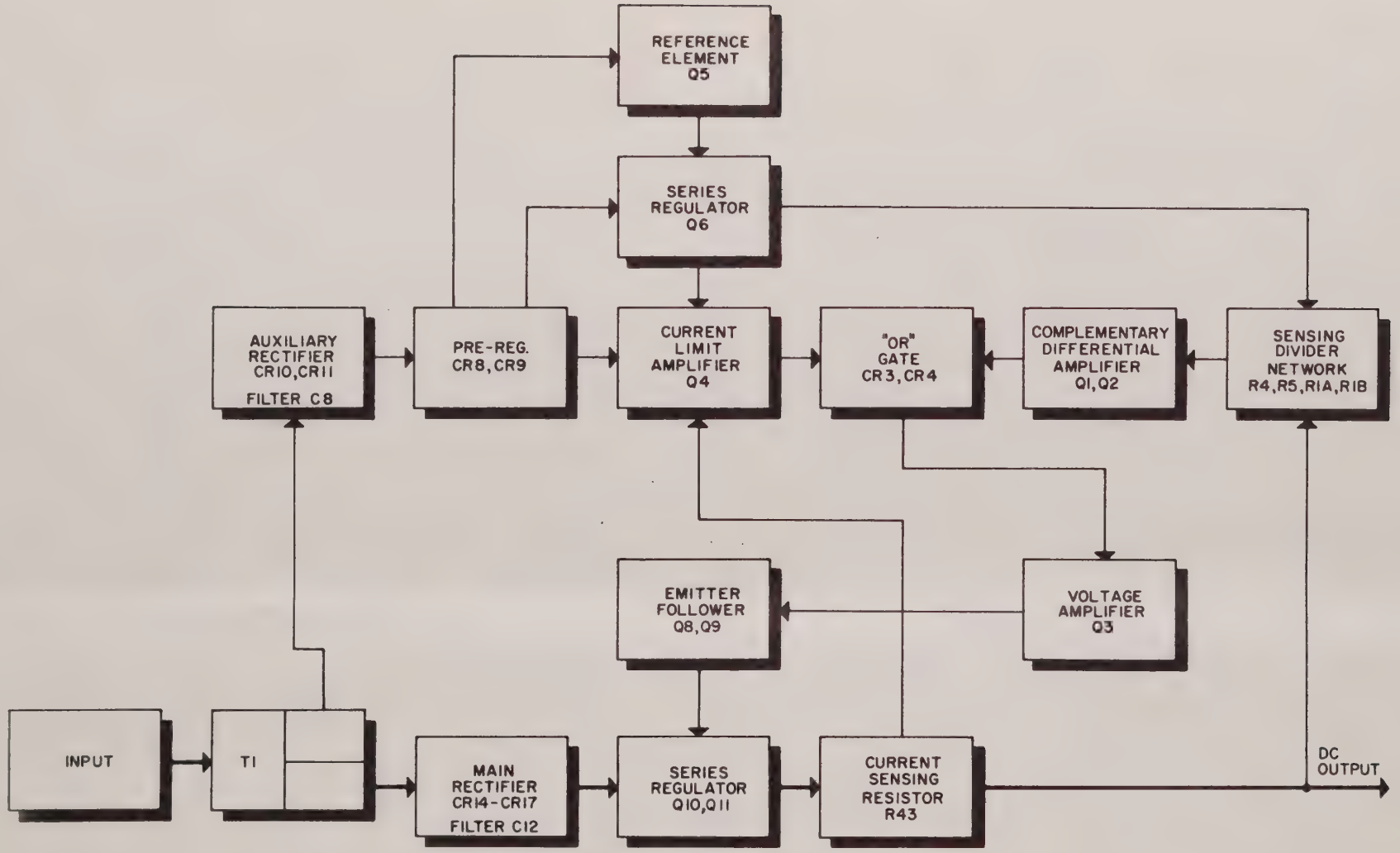
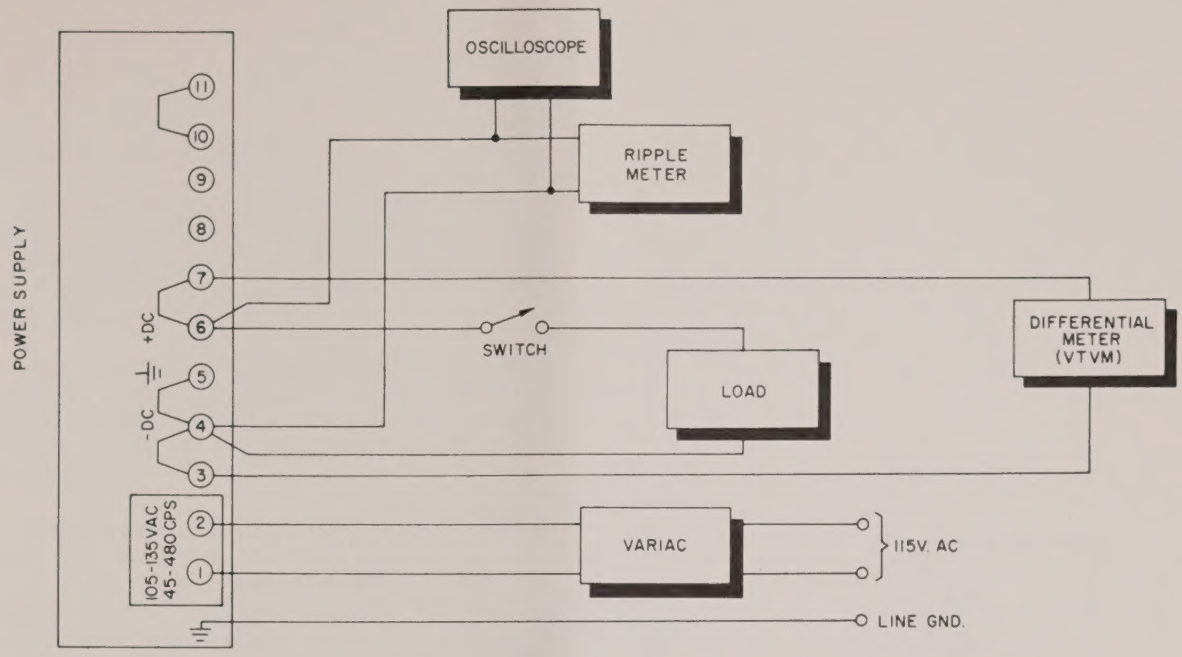


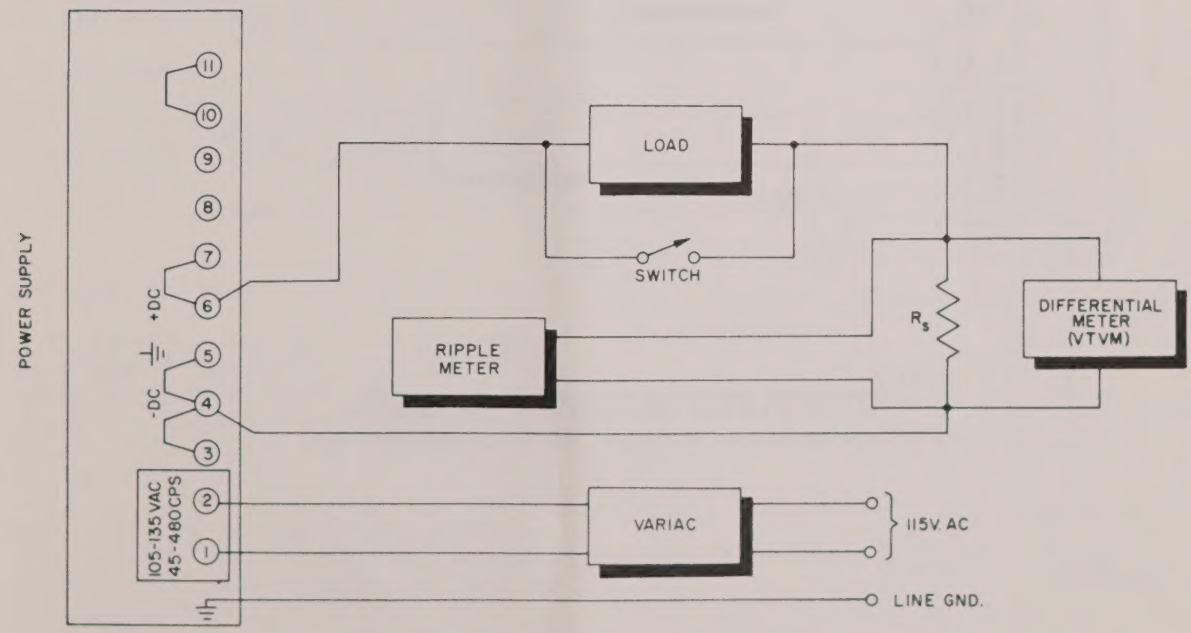
FIGURE 14. BLOCK DIAGRAM, CONSTANT VOLTAGE AND CONSTANT CURRENT CROSSOVER



NOTES:

1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

FIGURE 15. TEST CONNECTIONS FOR CONSTANT VOLTAGE PERFORMANCE CHECKS



NOTES:

1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

FIGURE 16. TEST CONNECTIONS FOR CONSTANT CURRENT PERFORMANCE CHECKS

PARTS LIST

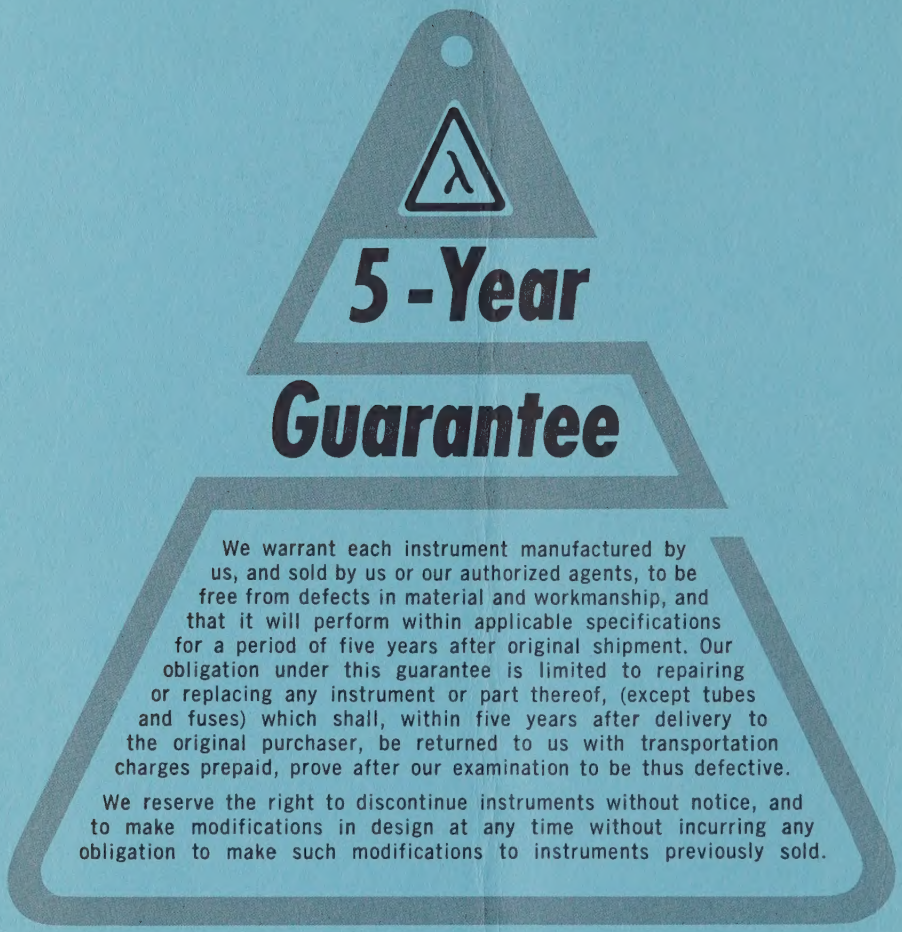
The electrical parts located on this model are listed here together with parts for models that carry the (FM) or (S) suffix.

MODELS LH 118, LH 118FM, LH 118S

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.	UNIT PRICE
C1*	Cap., tantalum, 2.5 mfd -15% +75% 100 vdc	CBN-25-010	$ 1.80
C2	Cap., elect. 1,000 mfd -10% +100%, 28 vdc, 40V surge	CBS-10-025	3.01
C3	Same as C1		
C4	Cap., mica, 470 mfd ±20%, 300 vdc	CCJ-47-004	.46
C5+	Cap., mylar, .0033 mfd ±10%, 200 vdc	CGK-33-003	.33
C5	Cap., mylar, .01 mfd ±10%, 200 vdc	CGL-10-002	.36
C6	Cap., mylar, .0068 mfd ±10%, 200 vdc	CGK-68-001	.34
C7	Cap., tantalum, 1.0 mfd ±20%, 35 vdc	CBN-10-009	1.33
C8	Cap., elect., 75 mfd -10% +100%, 55 vdc, 75V surge	CBP-75-009	1.96
C9	Cap., paper, .56 mfd ±10%, 400 vdc	CAM-56-011	3.82
C10, C11	Not assigned		
C12	Cap., elect. 4,300 mfd -10% +100%, 28 vdc, 40V surge	CBS-43-026	8.19
C13, C14	Not assigned		
C15	Cap., mylar, .0033 mfd ±10%, 200 vdc	CGK-33-003	.33
C16-C18	Not assigned		
C19	Cap., mylar, .10 mfd ±10%, 200 vdc	CAM-10-012	.65
CR1 thru CR7	Rectifier	FBL-00-030	1.40
CR8	Rectifier, zener diode	FBM-1N965B	1.15
CR9#	Rectifier, zener diode	FBM-1N3029B	7.10
CR9	Rectifier, zener diode	FBM-Z105	4.35
CR10, CR11	Rectifier	FBL-00-036	.60
CR12, CR13	Not assigned		

MODELS LH 118, LH 118FM, LH 118S (cont)

CIRC. DESIG.	DESCRIPTION	LAMBDA NO.	UNIT PRICE
CR14 thru CR17	Rectifier, silicon	FBL-00-054 or FBL-00-044	$ 1.35 1.18
CR18, CR19	Rectifier, silicon	FBL-00-054 or FBL-00-040	1.35 1.15
DS1°	Pilot Light Assembly	HRD-00-007	.83
F1	Fuse, cartridge, 3.0 amperes, 3AG, "SLO-BLO"	FFC-03-000	.18
M1*	Meter, volts DC, 0-10 VDC	EBP-10-016	18.00
M2*	Meter, amperes DC, 0-5 amperes	EDN-50-021	18.00
Q1	Transistor, PNP	FBN-L103	1.76
Q2, Q3, Q4	Transistor, NPN	FBN-L101	1.32
Q5	Transistor, reference element	FBN-L104	6.00
Q6	Transistor, NPN	FBN-L102	2.40
Q7	Not assigned		
Q8	Same as Q6		
Q9	Transistor, NPN	FBN-35469	4.29
Q10, Q11	Transistor, NPN	FBN-36220	6.60
R1	Res., two-section, var., 2,000 ohms total ±5%, 2W each section	DNS-20-018 or DNS-20-060	5.58
R2	Res., film, 2,400 ohms ±5%, 1/2W	DCS-24-001	0.25
R3	Res., ww, 6.2 ohms ±5%, 2W	DFN-62-045	.50
R4	Res., ww, 1,250 ohms ±1%, 2W	DES-12-010	.58
R5	Res., var., 600 ohms ±10%, 1-1/2W	DNR-60-012	1.25
R6	Res., comp., 150,000 ohms ±10%, 1/2W	DEB-1541	0.12
R7	Res., comp., 4,700 ohms ±10%, 1/2W	DEB-4721	0.12
R8	Res., comp., 8,200 ohms ±10%, 1/2W	DEB-8221	0.12
R9	Res., comp., 15,000 ohms ±10%, 1/2W	DEB-1531	0.12
R10	Res., comp., 39,000 ohms ±10%, 1/2W	DEB-3931	0.12


5 - Year
Guarantee
We warrant each instrument manufactured by us, and sold by us or our authorized agents, to be free from defects in material and workmanship, and that it will perform within applicable specifications for a period of five years after original shipment. Our obligation under this guarantee is limited to repairing or replacing any instrument or part thereof, (except tubes and fuses) which shall, within five years after delivery to the original purchaser, be returned to us with transportation charges prepaid, prove after our examination to be thus defective.
We reserve the right to discontinue instruments without notice, and to make modifications in design at any time without incurring any obligation to make such modifications to instruments previously sold.

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